



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 7, 2026 – 04:47 AM UTC

PDB ID : 1E12 / pdb_00001e12
Title : Halorhodopsin, a light-driven chloride pump
Authors : Essen, L.-O.; Kolbe, M.; Oesterhelt, D.
Deposited on : 2000-04-14
Resolution : 1.80 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	NOT EXECUTED
EDS	:	NOT EXECUTED
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

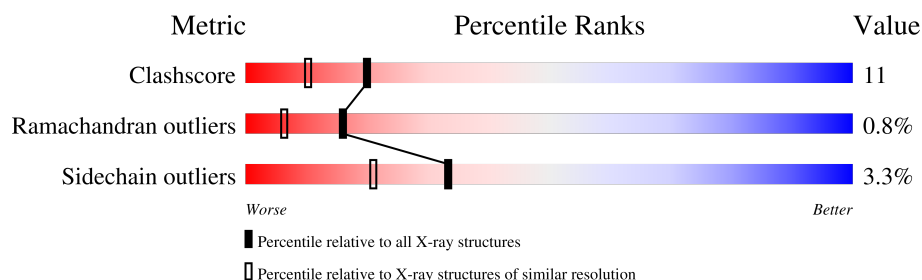
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.80 Å.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
Clashscore	190562	8479 (1.80-1.80)
Ramachandran outliers	187476	8391 (1.80-1.80)
Sidechain outliers	187428	8390 (1.80-1.80)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$.

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	253	 75% 16% • 6%

2 Entry composition

There are 7 unique types of molecules in this entry. The entry contains 2169 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called HALORHODOPSIN.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	239	Total	C	N	O	S	0	0	0
			1793	1187	288	308	10			

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	229	ALA	VAL	SEE REMARK 999	UNP P0DMH7

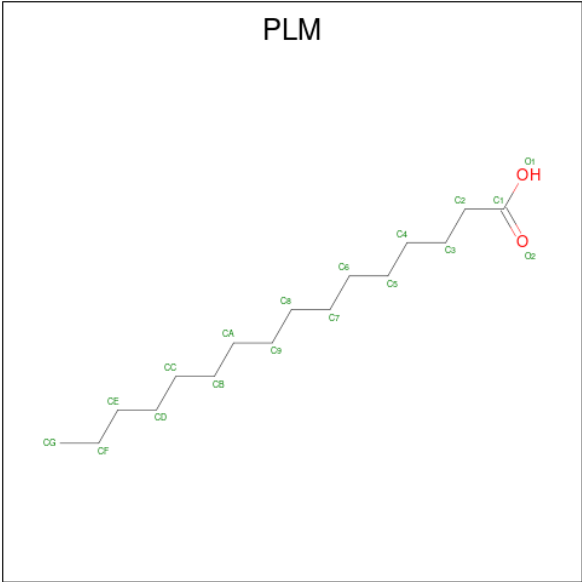
- Molecule 2 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Cl	0	0
			1	1		

- Molecule 3 is POTASSIUM ION (CCD ID: K) (formula: K).

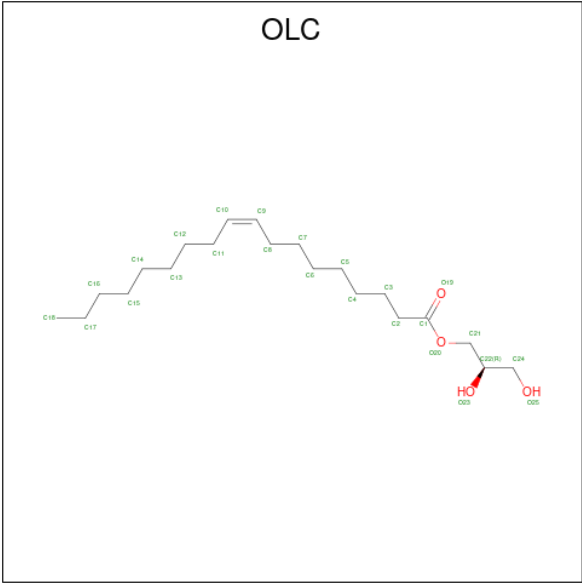
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total	K	0	0
			1	1		

- Molecule 4 is PALMITIC ACID (CCD ID: PLM) (formula: C₁₆H₃₂O₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	C	O	0	0
			18	16	2		

- Molecule 5 is (2R)-2,3-dihydroxypropyl (9Z)-octadec-9-enoate (CCD ID: OLC) (formula: C₂₁H₄₀O₄).



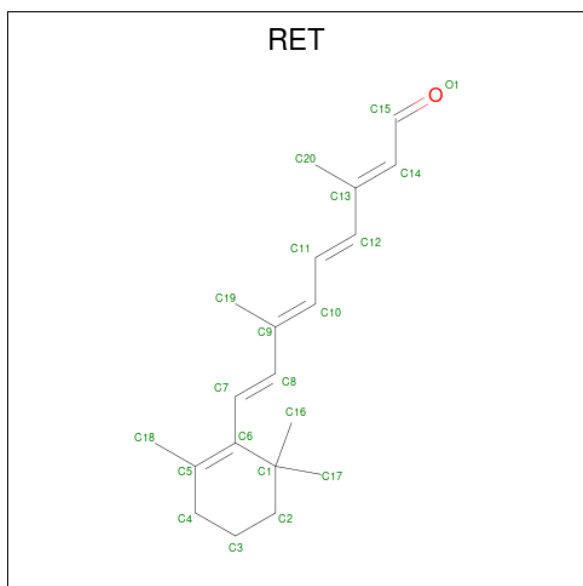
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total	C	O	5	0
			24	21	3		
5	A	1	Total	C	O	7	0
			24	21	3		

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Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total	C	O	12	0
			24	21	3		
5	A	1	Total	C	O	14	0
			24	21	3		
5	A	1	Total	C	O	0	0
			24	21	3		
5	A	1	Total	C	O	0	0
			24	21	3		
5	A	1	Total	C	O	5	0
			24	21	3		
5	A	1	Total	C	O	5	0
			24	21	3		
5	A	1	Total	C	O	5	0
			24	21	3		
5	A	1	Total	C	O	16	0
			24	21	3		

- Molecule 6 is RETINAL (CCD ID: RET) (formula: $C_{20}H_{28}O$).



Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	1	Total	C	0	0
			20	20		

- Molecule 7 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	A	96	Total 96	O 96	0	0

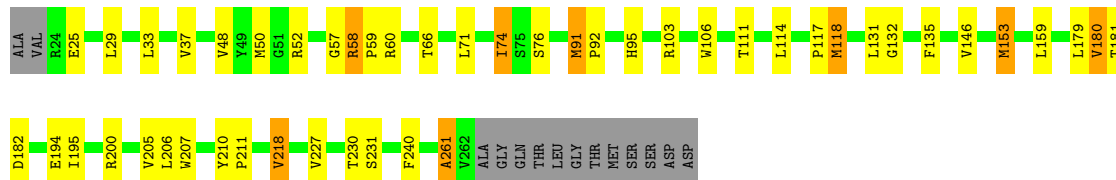
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry. Residues are color-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

Note EDS was not executed.

• Molecule 1: HALORHODOPSIN

Chain A:  75% 16% 6%



4 Data and refinement statistics

Xtriage (Phenix) and EDS were not executed - this section is therefore incomplete.

Property	Value	Source
Space group	P 63 2 2	Depositor
Cell constants a, b, c, α , β , γ	67.30Å 67.30Å 209.20Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	25.00 – 1.80	Depositor
% Data completeness (in resolution range)	98.1 (25.00-1.80)	Depositor
R_{merge}	0.05	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	CNS 0.9	Depositor
R, R_{free}	0.237 , 0.257	Depositor
Estimated twinning fraction	No twinning to report.	Xtriage
Total number of atoms	2169	wwPDB-VP
Average B, all atoms (Å ²)	33.0	wwPDB-VP

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: K, OLC, PLM, CL, RET

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	$\# Z > 5$	RMSZ	$\# Z > 5$
1	A	1.03	2/1836 (0.1%)	1.16	11/2517 (0.4%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	91	MET	SD-CE	-9.18	1.56	1.79
1	A	153	MET	SD-CE	5.18	1.92	1.79

All (11) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	210	TYR	CA-C-N	-6.72	112.77	119.56
1	A	210	TYR	C-N-CA	-6.72	112.77	119.56
1	A	218	VAL	N-CA-C	6.45	117.98	110.62
1	A	218	VAL	CB-CA-C	-6.29	103.80	112.04
1	A	37	VAL	N-CA-C	-6.20	104.29	110.62
1	A	118	MET	CG-SD-CE	-6.05	87.60	100.90
1	A	48	VAL	N-CA-C	-5.98	104.68	110.42
1	A	205	VAL	N-CA-C	5.67	115.87	110.42
1	A	132	GLY	N-CA-C	-5.50	106.12	112.50
1	A	261	ALA	N-CA-C	-5.38	105.97	112.54
1	A	50	MET	N-CA-C	5.19	116.94	111.28

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts ⓘ

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	1793	0	1844	39	0
2	A	1	0	0	0	0
3	A	1	0	0	0	0
4	A	18	0	31	5	0
5	A	240	0	400	7	0
6	A	20	0	27	3	0
7	A	96	0	0	1	0
All	All	2169	0	2302	48	0

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 11.

All (48) close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:71:LEU:HD23	1:A:74:ILE:HD11	1.48	0.96
1:A:58:ARG:HE	1:A:58:ARG:H	1.15	0.94
1:A:91:MET:HE3	1:A:92:PRO:HD2	1.49	0.92
1:A:52:ARG:HH11	1:A:52:ARG:HG3	1.42	0.83
1:A:91:MET:HE2	1:A:95:HIS:CD2	2.17	0.80
1:A:194:GLU:H	1:A:194:GLU:CD	1.96	0.74
1:A:114:LEU:O	1:A:118:MET:HG3	1.94	0.68
1:A:52:ARG:HG3	1:A:52:ARG:NH1	2.05	0.65
1:A:58:ARG:HB2	1:A:59:PRO:HD3	1.81	0.62
1:A:58:ARG:H	1:A:58:ARG:NE	1.93	0.61
1:A:135:PHE:CE1	4:A:700:PLM:HF2	2.36	0.60
5:A:711:OLC:H11	5:A:717:OLC:H16	1.83	0.60
1:A:194:GLU:HG2	1:A:195:ILE:H	1.70	0.57
1:A:106:TRP:HB3	1:A:153:MET:HE3	1.87	0.56
1:A:227:VAL:O	1:A:230:THR:HG22	2.05	0.56
5:A:701:OLC:H4A	5:A:719:OLC:H3A	1.87	0.56
1:A:58:ARG:NH1	1:A:261:ALA:O	2.38	0.56
1:A:159:LEU:HD23	5:A:709:OLC:H24A	1.87	0.56
5:A:711:OLC:H13A	5:A:717:OLC:H14A	1.87	0.56
1:A:58:ARG:HE	1:A:58:ARG:N	1.96	0.54

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
5:A:709:OLC:H21	5:A:709:OLC:H3A	1.89	0.54
1:A:57:GLY:HA3	1:A:58:ARG:HH21	1.74	0.52
1:A:135:PHE:HE1	4:A:700:PLM:HF2	1.74	0.52
1:A:194:GLU:HG2	1:A:195:ILE:N	2.25	0.50
1:A:29:LEU:HD21	1:A:103:ARG:NE	2.28	0.49
6:A:999:RET:H8	6:A:999:RET:H171	1.94	0.49
1:A:182:ASP:OD1	1:A:182:ASP:C	2.55	0.48
1:A:179:LEU:HB3	1:A:200:ARG:HG3	1.95	0.48
5:A:713:OLC:H14A	5:A:715:OLC:H11	1.96	0.47
1:A:182:ASP:OD1	1:A:182:ASP:O	2.32	0.47
1:A:206:LEU:HD11	1:A:240:PHE:HB3	1.96	0.47
1:A:135:PHE:HE1	4:A:700:PLM:CG	2.27	0.47
1:A:60:ARG:HD3	7:A:2012:HOH:O	2.15	0.46
6:A:999:RET:H7	6:A:999:RET:H181	1.79	0.46
1:A:180:VAL:HG12	1:A:180:VAL:O	2.16	0.45
5:A:713:OLC:H6	5:A:715:OLC:H7	1.99	0.45
1:A:114:LEU:C	1:A:117:PRO:HD2	2.42	0.45
1:A:135:PHE:HE1	4:A:700:PLM:CF	2.30	0.44
1:A:146:VAL:HG11	4:A:700:PLM:H32	1.99	0.44
1:A:71:LEU:O	1:A:74:ILE:HG12	2.18	0.44
1:A:76:SER:HB2	1:A:111:THR:HG21	1.99	0.43
6:A:999:RET:H171	6:A:999:RET:C8	2.48	0.43
1:A:227:VAL:C	1:A:230:THR:HG22	2.44	0.43
1:A:181:THR:OG1	1:A:182:ASP:N	2.51	0.42
1:A:179:LEU:C	1:A:200:ARG:HD2	2.45	0.41
1:A:52:ARG:NH1	1:A:52:ARG:CG	2.76	0.40
1:A:207:TRP:O	1:A:211:PRO:HD2	2.21	0.40
1:A:230:THR:HG23	1:A:231:SER:N	2.36	0.40

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	237/253 (94%)	232 (98%)	3 (1%)	2 (1%)	16	6

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	25	GLU
1	A	180	VAL

5.3.2 Protein sidechains ⓘ

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	183/196 (93%)	177 (97%)	6 (3%)	33	21

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	33	LEU
1	A	58	ARG
1	A	66	THR
1	A	74	ILE
1	A	131	LEU
1	A	218	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 14 ligands modelled in this entry, 2 are monoatomic - leaving 12 for Mogul analysis.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	# Z > 2	Counts	RMSZ	# Z > 2
5	OLC	A	709	-	23,23,24	0.37	0	23,23,25	0.69	0
6	RET	A	999	1	20,20,21	4.72	8 (40%)	27,27,28	1.67	7 (25%)
5	OLC	A	701	-	23,23,24	0.35	0	23,23,25	0.65	0
5	OLC	A	703	-	23,23,24	0.35	0	23,23,25	0.58	0
5	OLC	A	711	-	23,23,24	0.42	0	23,23,25	0.45	0
5	OLC	A	705	-	23,23,24	0.45	0	23,23,25	0.54	0
5	OLC	A	715	-	23,23,24	0.30	0	23,23,25	0.54	0
5	OLC	A	717	-	23,23,24	0.45	0	23,23,25	0.46	0
5	OLC	A	719	-	23,23,24	0.29	0	23,23,25	0.65	0
5	OLC	A	707	-	23,23,24	0.34	0	23,23,25	0.55	0
5	OLC	A	713	-	23,23,24	0.32	0	23,23,25	0.67	0
4	PLM	A	700	-	17,17,17	0.60	0	17,17,17	1.17	2 (11%)

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
5	OLC	A	709	-	-	2/22/22/24	-
6	RET	A	999	1	-	1/13/30/31	0/1/1/1
5	OLC	A	701	-	-	4/22/22/24	-
5	OLC	A	703	-	-	4/22/22/24	-
5	OLC	A	711	-	-	3/22/22/24	-
5	OLC	A	705	-	-	4/22/22/24	-

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Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
5	OLC	A	715	-	-	6/22/22/24	-
5	OLC	A	717	-	-	6/22/22/24	-
5	OLC	A	719	-	-	6/22/22/24	-
5	OLC	A	707	-	-	4/22/22/24	-
5	OLC	A	713	-	-	3/22/22/24	-
4	PLM	A	700	-	-	1/15/15/15	-

All (8) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
6	A	999	RET	C14-C13	-18.29	1.21	1.33
6	A	999	RET	C5-C6	5.01	1.42	1.34
6	A	999	RET	C1-C6	4.60	1.59	1.53
6	A	999	RET	C11-C12	3.95	1.45	1.34
6	A	999	RET	C19-C9	3.60	1.58	1.50
6	A	999	RET	C4-C5	3.49	1.57	1.51
6	A	999	RET	C18-C5	2.34	1.54	1.50
6	A	999	RET	C8-C7	2.06	1.39	1.33

All (9) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
6	A	999	RET	C7-C8-C9	-3.93	120.42	126.23
6	A	999	RET	C18-C5-C6	-2.88	121.34	124.48
6	A	999	RET	C10-C11-C12	-2.58	115.72	123.20
4	A	700	PLM	O2-C1-C2	-2.53	115.07	123.09
4	A	700	PLM	O1-C1-C2	2.50	121.90	114.00
6	A	999	RET	C1-C6-C7	2.30	121.90	115.65
6	A	999	RET	C19-C9-C8	2.08	121.26	118.09
6	A	999	RET	C3-C4-C5	-2.05	110.39	114.06
6	A	999	RET	C11-C10-C9	-2.02	124.44	127.28

There are no chirality outliers.

All (44) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	A	703	OLC	O20-C21-C22-C24
5	A	703	OLC	O20-C21-C22-O23
5	A	717	OLC	O20-C21-C22-C24
5	A	717	OLC	O20-C21-C22-O23

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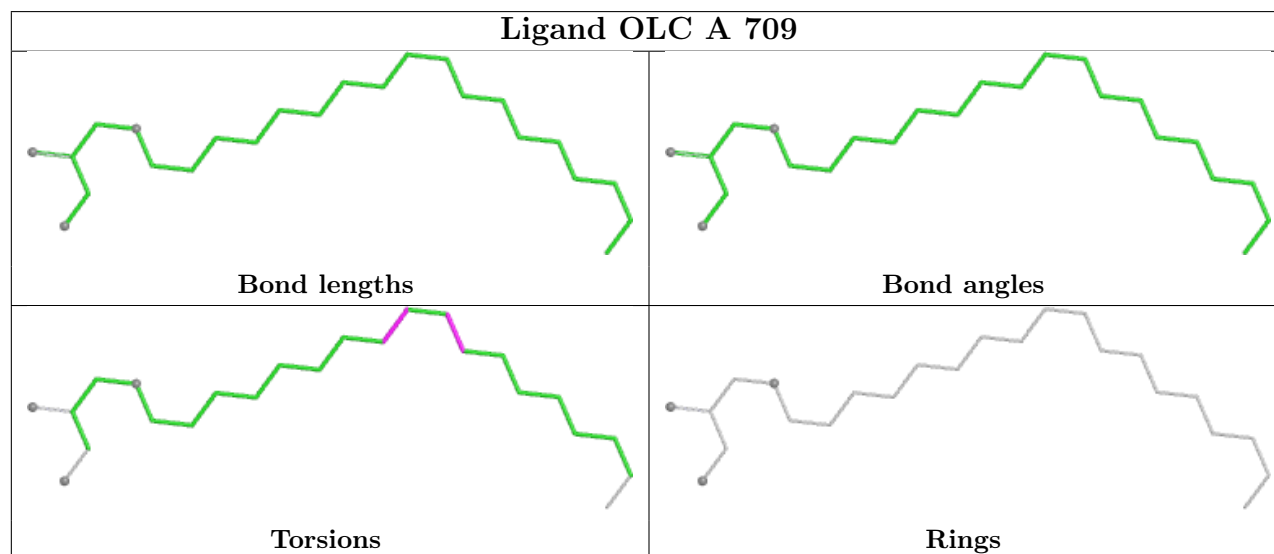
Mol	Chain	Res	Type	Atoms
5	A	719	OLC	O20-C21-C22-C24
5	A	719	OLC	O20-C21-C22-O23
5	A	705	OLC	O20-C21-C22-C24
5	A	707	OLC	O20-C21-C22-O23
5	A	705	OLC	O20-C21-C22-O23
5	A	707	OLC	O20-C21-C22-C24
5	A	717	OLC	C12-C13-C14-C15
5	A	717	OLC	C11-C12-C13-C14
5	A	717	OLC	C5-C6-C7-C8
5	A	713	OLC	C11-C12-C13-C14
5	A	715	OLC	C13-C14-C15-C16
5	A	713	OLC	O20-C21-C22-O23
5	A	715	OLC	C12-C13-C14-C15
5	A	701	OLC	O20-C1-C2-C3
5	A	717	OLC	C6-C7-C8-C9
5	A	719	OLC	C9-C10-C11-C12
5	A	715	OLC	C11-C12-C13-C14
5	A	703	OLC	C7-C8-C9-C10
5	A	711	OLC	C7-C8-C9-C10
4	A	700	PLM	C4-C5-C6-C7
5	A	711	OLC	C9-C10-C11-C12
5	A	715	OLC	C9-C10-C11-C12
5	A	701	OLC	C2-C1-O20-C21
5	A	705	OLC	C9-C10-C11-C12
5	A	701	OLC	C7-C8-C9-C10
5	A	705	OLC	C7-C8-C9-C10
5	A	707	OLC	C9-C10-C11-C12
5	A	703	OLC	C9-C10-C11-C12
5	A	709	OLC	C9-C10-C11-C12
5	A	707	OLC	C7-C8-C9-C10
5	A	719	OLC	C7-C8-C9-C10
6	A	999	RET	C12-C13-C14-C15
5	A	701	OLC	C9-C10-C11-C12
5	A	709	OLC	C7-C8-C9-C10
5	A	715	OLC	C7-C8-C9-C10
5	A	715	OLC	C6-C7-C8-C9
5	A	713	OLC	C12-C13-C14-C15
5	A	719	OLC	C22-C21-O20-C1
5	A	719	OLC	C2-C1-O20-C21
5	A	711	OLC	C15-C16-C17-C18

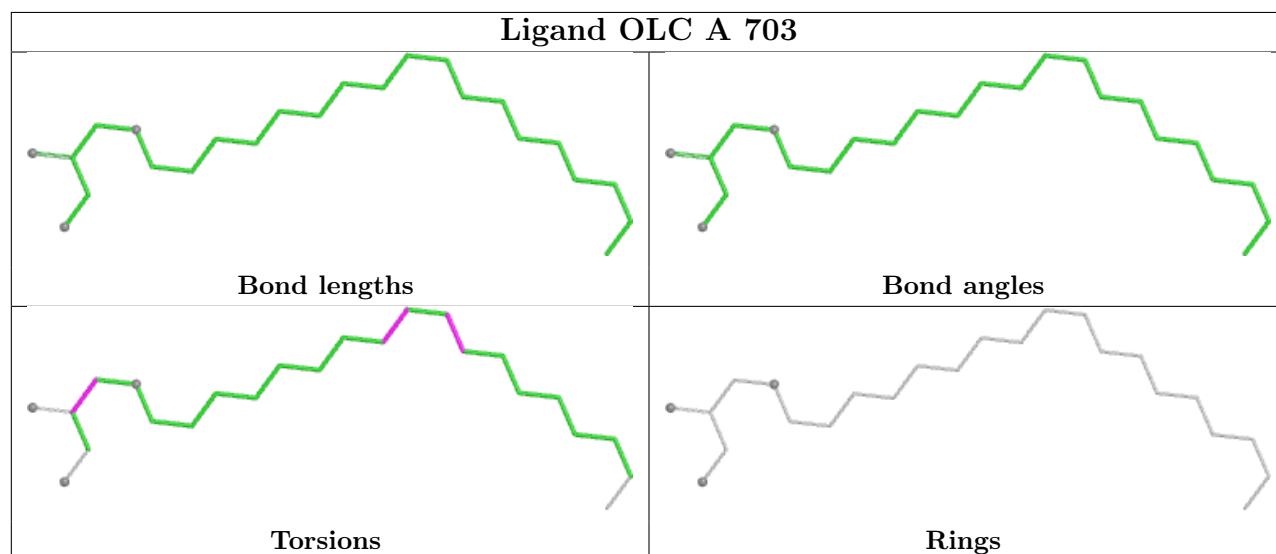
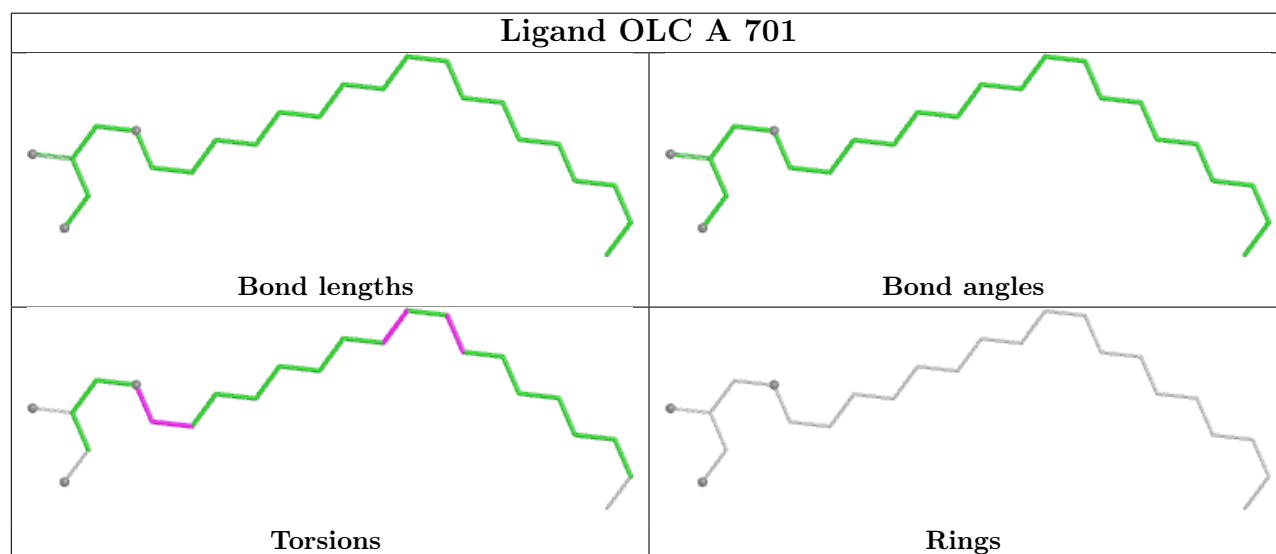
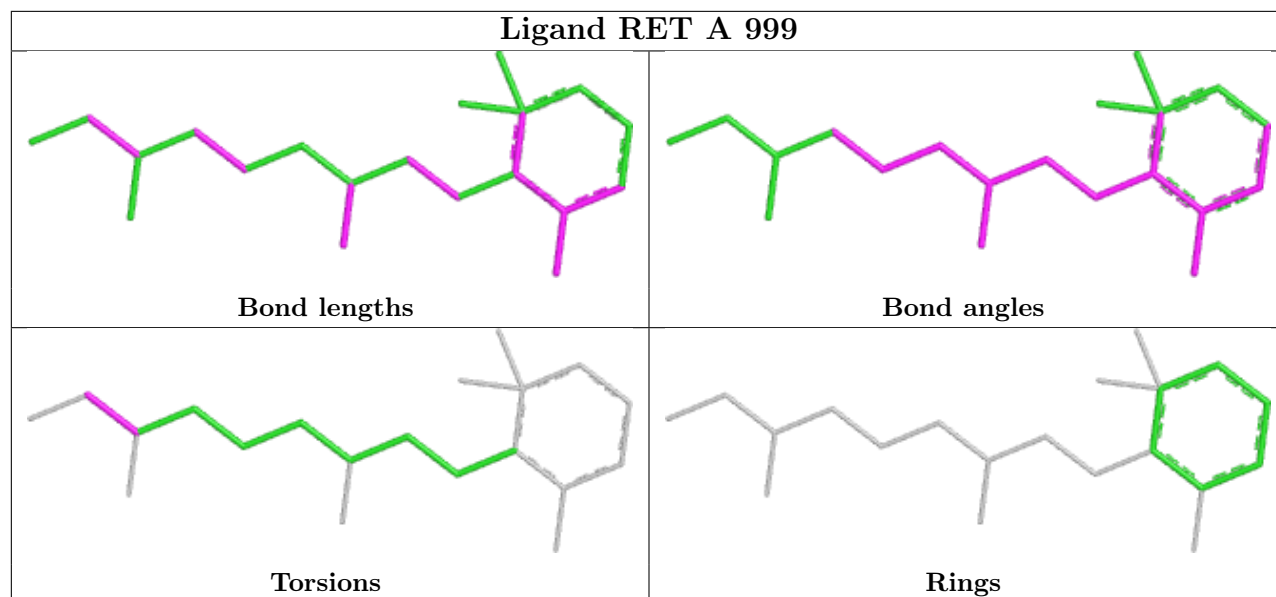
There are no ring outliers.

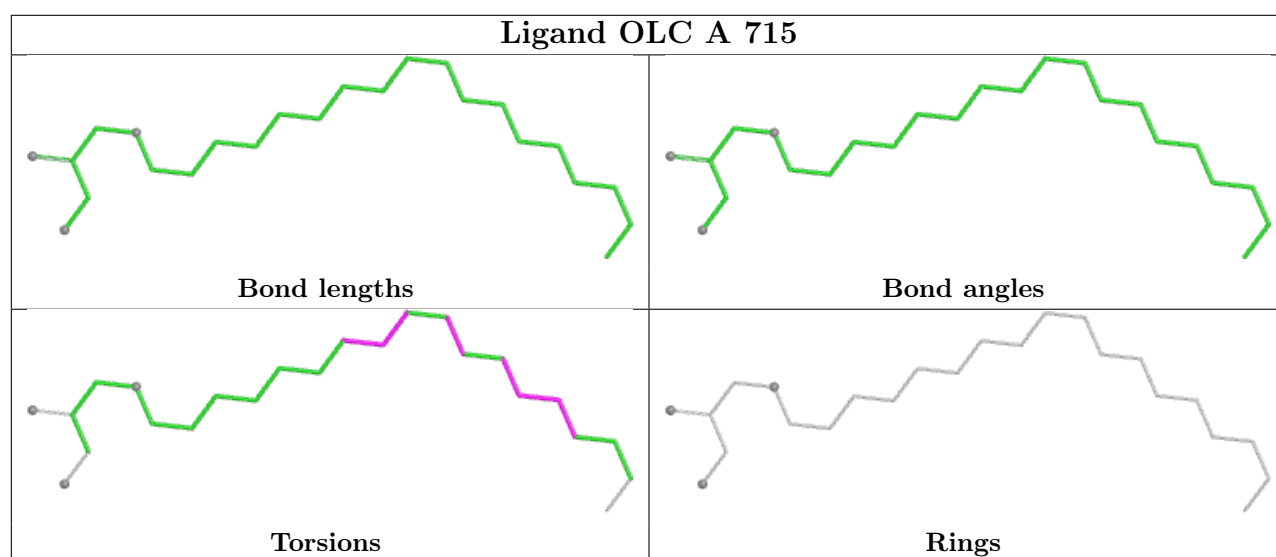
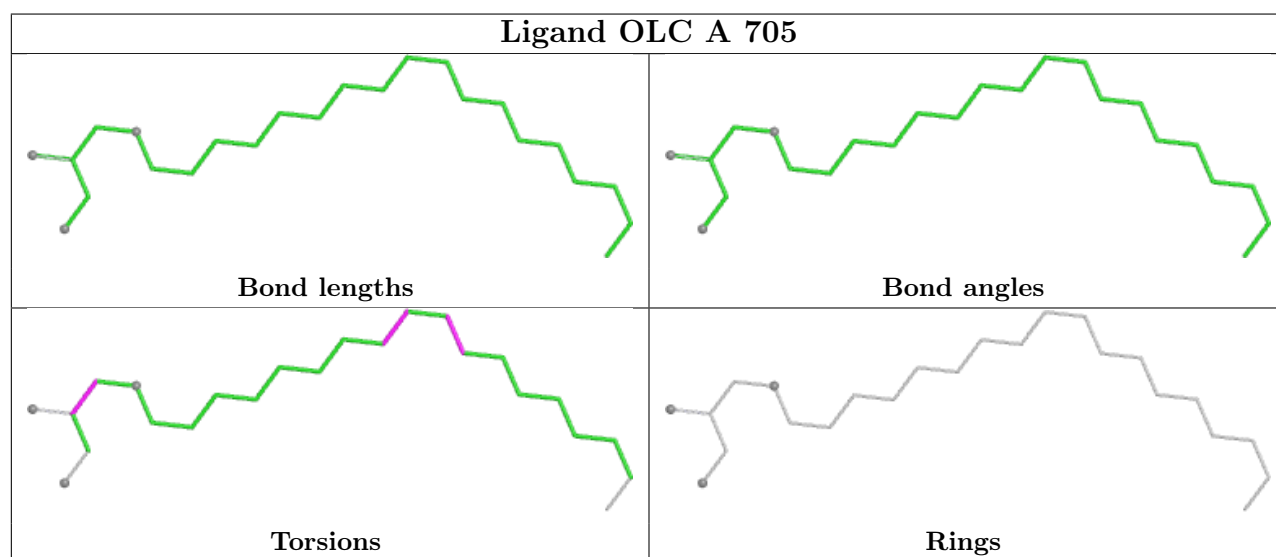
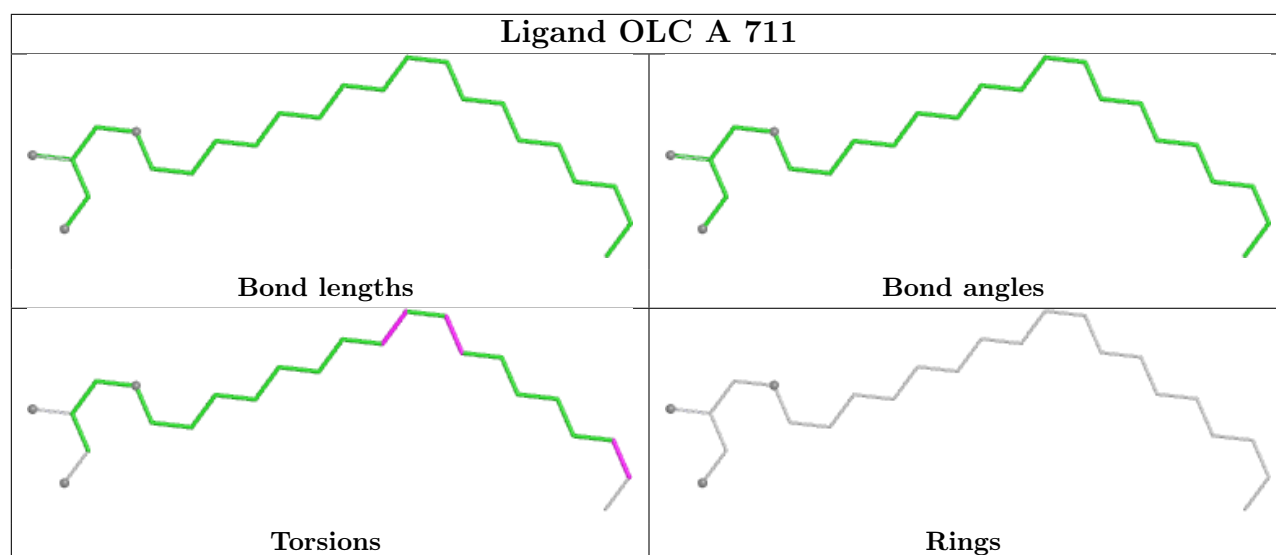
9 monomers are involved in 15 short contacts:

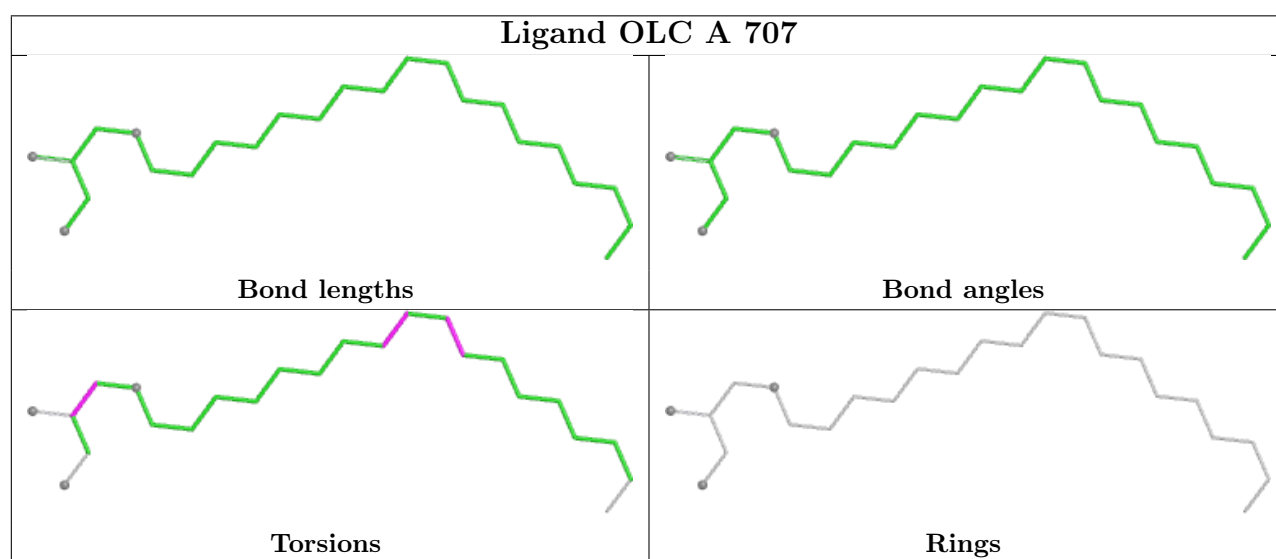
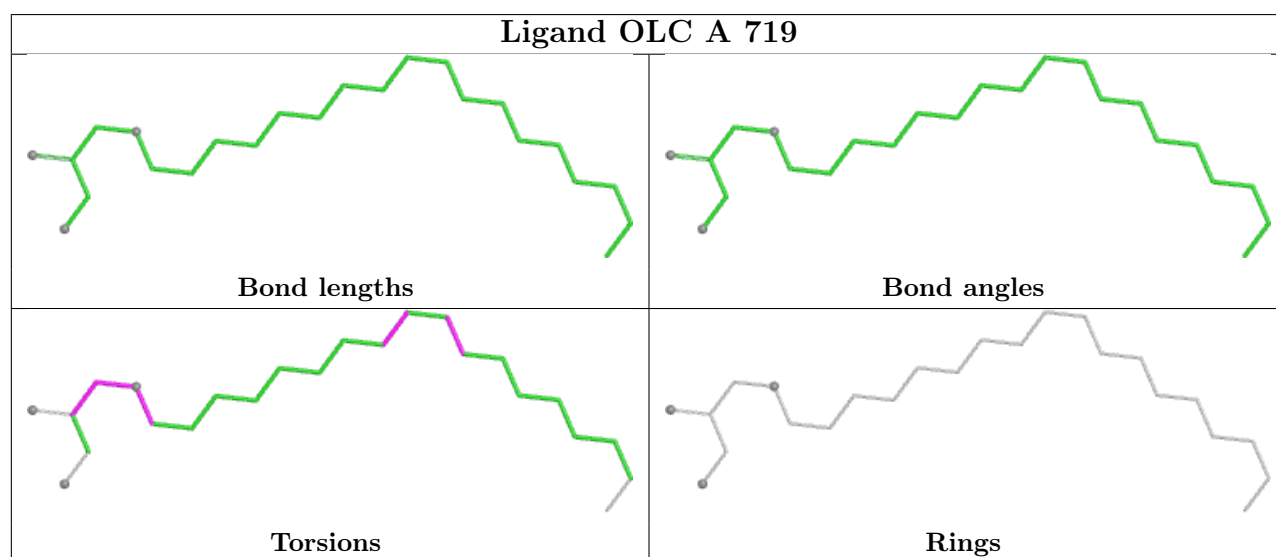
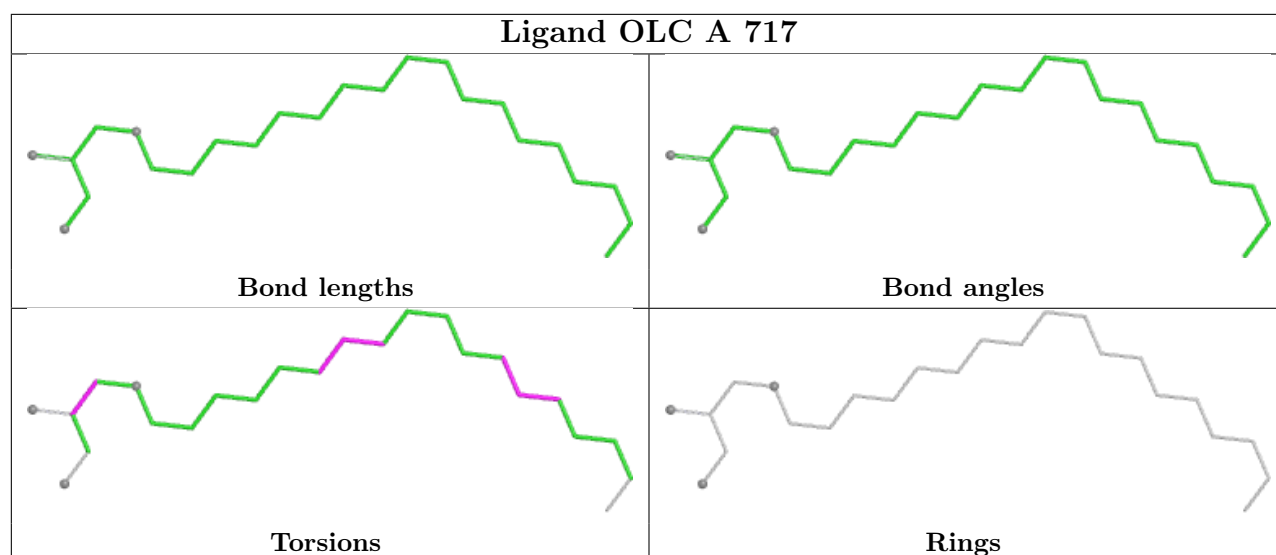
Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	A	709	OLC	2	0
6	A	999	RET	3	0
5	A	701	OLC	1	0
5	A	711	OLC	2	0
5	A	715	OLC	2	0
5	A	717	OLC	2	0
5	A	719	OLC	1	0
5	A	713	OLC	2	0
4	A	700	PLM	5	0

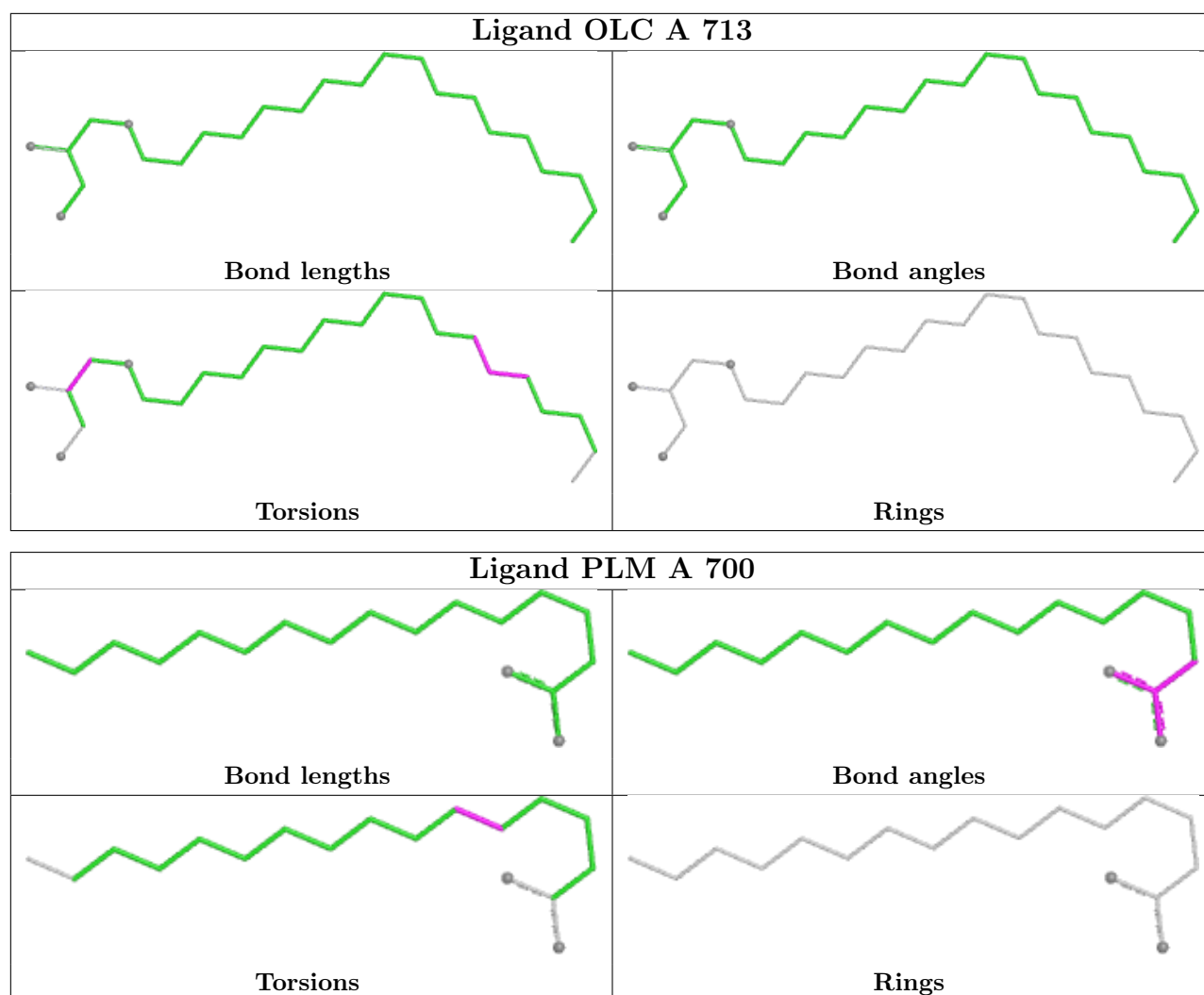
The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.











5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

EDS was not executed - this section is therefore empty.

6.2 Non-standard residues in protein, DNA, RNA chains

EDS was not executed - this section is therefore empty.

6.3 Carbohydrates

EDS was not executed - this section is therefore empty.

6.4 Ligands

EDS was not executed - this section is therefore empty.

6.5 Other polymers

EDS was not executed - this section is therefore empty.